



(19)

Europäisches Patentamt

European Patent Office

Office européen des brevets



(11)

EP 0 721 228 A1

(12)

EUROPEAN PATENT APPLICATION

(43) Date of publication:
10.07.1996 Bulletin 1996/28(51) Int. Cl.⁶: H01M 2/36

(21) Application number: 95309374.7

(22) Date of filing: 21.12.1995

(84) Designated Contracting States:
DE FR GB

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Designated Contracting States:

DE

(30) Priority: 06.01.1995 US 369636

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(54) Automatic battery watering system

(57) A battery watering (8) system using a plurality of cells (14) and modules (12). Watering ramps (11) communicate water from a reservoir (18) to a series of interconnected watering caps (16). A reversible pump (30) is positioned below the watering caps (16) such that water within the watering caps (16) and interconnecting conduits (26, 28) drains through the pump (30) and into the

reservoir (18) by syphon when no voltage is applied to the pump (30). A controller (39) automatically operates the watering system (8) by sensing the amp hours used since the last watering and determines whether or not the battery needs water. Successful battery watering or system failure are signalled (40) to the operator.

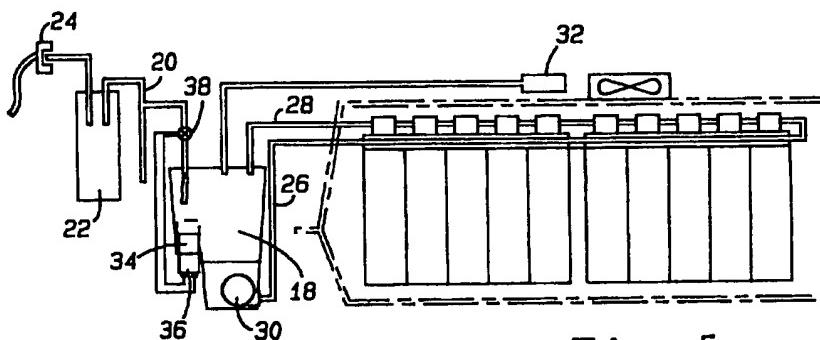


Fig-5

EP 0 721 228 A1

Description

The present invention relates to an automatic watering system for batteries. More specifically, the invention relates to a watering system having a gravity siphon to drain excess water from the battery through a reversible pump and a method for automatically operating the watering system.

High power and high voltage batteries are useful in commercial and industrial applications. One application requiring a high voltage and high powered battery is electric vehicles. Several types of electric vehicle batteries require periodic replenishment of electrolyte, including lead acid, nickel cadmium and nickel metal hydride. Recharging the battery causes an electrolysis of the water and results in the evolution of gas. Water is added to the battery cells to maintain an equilibrium of the electrolyte and to completely wet the cell surfaces.

A number of battery watering systems are known in the prior art. Typical of the known automatic watering systems for batteries is U.S. Patent No. 4,522,896, issued June 11, 1985 to Isard. Isard teaches a battery having a series of connected cells. Each cell has an associated watering cap and an interconnecting means receiving electrolyte from a reservoir. The interconnecting means, reservoir and caps form an essentially closed system. The reservoir selectively communicates with a watering pump, watering cap and flame trap. The interconnecting means also includes a gas purging means to selectively open the closed system to the atmosphere. Gas is selectively purged from within the system during the operation of a gas purging cycle.

Isard requires either a combination liquid/gas type pump such as a diaphragm or peristaltic type pump or the use of a separate air pump to force air through the interconnecting means. Isard does not teach an automatic watering system to alert the operator to a low water condition, operate the pumps and valves to water the battery to the appropriate fill level and detect a fault condition.

U.S. patent No. 4,399,200, issued August 16, 1983 to Galloway, teaches a method for controlling a pump in a storage battery. Galloway teaches applying of variable electric voltage to the pump motor to control the flow rate into the battery. This invention is primarily intended for halogen hydride type electric storage batteries and does not detect low electrolyte levels within the battery nor automatically watering each cell in a battery.

The present invention overcomes the deficiencies of the prior art by using a low cost reversible pump to provide water to a battery. The watering caps and conduit are purged of excess water through a gravity siphon. A controller senses water usage to detect proper system operation and disables the charging system to prevent battery damage due to a lapse in watering maintenance.

The present invention provides a battery watering system for a battery having a plurality of cells connected in series. A watering cap associated with each cell receives water from a reservoir through a first watering

conduit. A reversible pump communicates water from the reservoir through the first watering conduit. A second watering conduit communicates flow through water from the watering caps back to the reservoir. The pump is positioned below the watering caps such that water within the watering caps and the second watering conduit drains through the pump by siphon when no voltage is applied to the pump.

The invention may be used with a large electric vehicle made up of a series of interconnected modules. A watering ramp provides water to one or more modules. Each watering ramp has its own reservoir, pump and watering conduits. The battery modules are usually electrically connected in series to provide a high voltage. The watering ramps are only exposed to the voltage of their associated modules and are not exposed to the total battery voltage.

The vehicle controller may be optionally used to control the operation of the watering system. The controller senses the amp hours used since the last watering and determines if the battery needs water. The controller operates the pump and related components to provide water to the battery. After every cell is filled, the controller shuts power to the pump. Water within the watering caps and watering conduits drains through the reversible pump by a gravity siphon.

The system provides for the automatic watering of separate watering ramps so that no portion of the watering system is exposed to the total battery voltage. The watering system signals an operator of successful battery watering or system failure. Low cost reversible pumps permit water to drain from the watering system by gravity siphon and thus eliminate the need for costly sealing pumps or separate air pumps.

The invention will now be described further, by way of example, with reference to the accompanying drawings, in which:

Figure 1 is a pictorial block schematic of an automatic watering system of the present invention showing the relative elevational disposition of the components;
 Figure 2 is a side view of the watering system illustrating a gassing condition of the battery;
 Figure 3 is a side view of the watering system illustrating cell watering;
 Figure 4 is a side view of the watering system illustrating watering flow-through of the cells;
 Figure 5 is a side view of the watering system illustrating siphon evacuation of the cell caps;
 Figure 6 is an electrical schematic of the watering system;
 Figures 7-9 are flow charts illustrating the operation of the watering system; and
 Figure 10 is a timing diagram of the watering system during and after cell watering.

An embodiment of the invention is illustrated in Figure 1. Automatic battery watering system 8 provides

water on an 'as needed' basis to battery 10. Battery 10 is arranged to include 7 separate watering ramps 11. Each watering ramp 11 includes two modules 12 connected in series. Each module 12 contains a series of interconnected cells 14. Each cell 14 has an associated watering cap 16 that provides water to the cell and vents gas evolution from the cell. Each watering ramp 11 is associated with a reservoir 18. The invention is primarily intended for use with high voltage and high powered batteries which are typically used in electric vehicle applications. To reduce the electrical hazards of watering this type of battery, the watering system is designed so that no portion of watering system 8 is exposed to the total battery voltage.

Reservoir 18 is a generally vertical container receiving deionised water from watering manifold 20. Deioniser 22 receives tap water hose 24 and removes unwanted ions. Reservoir 18 is connected to ramp 11 through fill/drain conduit 26 and overflow conduit 28. Conduit 26 provides water to cell cap 16 and drains unused water within the cell caps and conduit to reservoir 18. When cells 14 are fully watered, excess water flows through cell caps 16 and returns to reservoir 18 through conduit 28. After cell watering is completed, power to pump 30 is removed and water within cell caps 16 and conduit 28 drains into reservoir 18 by a gravity siphon through conduit 26.

Reversible pump 30 operates in a manner to pump water through conduit 26 and cell caps 16 when power is applied to the pump motor (pump motor not separately shown). When power is removed from the pump, pump 30 permits the reverse flow of water into the reservoir. Pump 30 does not operate in a reverse mode. Pump 30 need only permit the reverse flow of water through the pump by siphon. Representative reversible pumps include centrifugal, propeller, or turbine type pumps. Sealing type pumps such as diaphragms, peristolic and piston pumps do not generally permit a reverse flow of water through the pump and are therefore not suitable for the present invention.

Reservoir 18, conduit 28 and watering caps 16 are continuously vented through combustible vapour vent 32. Isolation of the ramps during venting limits the loss of modules to that ramp in the event of ignition. Reservoir 18 may be located immediately adjacent or attached to battery 12 or at a location remote from battery 12. Reservoir 18 is positioned below the height of cell caps 16 to drain water within cell caps 16 and conduits 26, 28 by gravity siphon. The cell caps and conduit should be drained of water to prevent current flow through the watering conduits and to alleviate the problem of water freezing within the conduits and cell caps. Reservoir 18, manifold 20 and conduits 26, 28 are usually insulated or optionally heated to prevent freezing. The invention provides for an open system that permits the continuous exhaust of vapours generated during the battery operation or charging. As will be more fully described below, valve 38 operates to replenish reservoir 18 with deionised water.

Figures 2-5 generally illustrate the operation of the battery before, during and after cell watering. Figure 2 illustrates a gassing condition occurring during cell overcharge. Nickel based batteries generally require overcharge to bring the nickel electrode up to 100% of electron capacity. Overcharge of the battery occurs when energy applied to the battery during charging converts water in the electrolyte to gas through electrolysis. The negative electrode (cadmium or hydride) is generally fully charged before the positive electrode (nickel). The charging energy necessary to bring the nickel electrode to 100 percent of capacity is generally between 15 and 20 percent of the total energy used in recharging and results in gas generation. Gas exit cells 14 through watering caps 16 and is vented through conduit 28 and vent 32. After sufficient time passes so that the positive electrode is totally restored to 100 percent of capacity, the system initiates the watering process.

Figure 3 illustrates cell watering. At the completion of overcharge, power is applied to pump 30. Pump 30 supplies water to watering caps 16 to fill cells 14. After each individual cell 14 is filled to capacity, the overflow travels through conduit 28 into reservoir 18. A period of overflow assures that each cell is completely replenished with water as shown in Figure 4. After the flow through period, power is removed from pump 30 as shown in Figure 5. Water within conduits 26, 28 drains through pump 30 and into reservoir 18 by a gravity siphon. Pump 30 need not be hydraulically reversible, it need only permit the reverse flow of fluid through the pump. Float 34 senses the water level within reservoir 18 and closes reed switch 36 when the water level drops below a pre-defined threshold. Switch 36 causes solenoid valve 38 to open and admit pressurised deionised water into reservoir 18. As the water level in reservoir 18 rises, float 34 causes switch 36 to close valve 38 after reservoir 18 is filled sufficiently. Gas within reservoir 18 is displaced by the replenishing water and is exhausted through vent 32.

Electrical schematic of Figure 6 illustrates the circuitry used by battery watering system 8. Controller 39 (CNTR) is a microprocessor that operates the various electrical components of watering system 8. Controller 39 may be used solely for purposes of the watering system or alternatively it may be a general purpose microprocessor used in the operation of the vehicle or the vehicle charging system. Indicator light 40, mounted in the vicinity of the charger connection, signals that the battery cells need water. Relay contacts 42, 44 provide power to pumps 30 and solenoid valves 38 respectively. Hose detection circuit 46 signals if watering hose 24 is connected to deioniser 22.

The control parameters for watering system 8 are illustrated in Figures 7-9. Beginning in Figure 7, an external electrical source attaches to the vehicle charger. Controller 39 senses the total amount of amp-hours passing through battery 10 during overcharge (C_{ah}). If C_{ah} is greater than constant C_2 , then the amount of overcharge that has occurred in battery 10 has probably elec-

trolysed sufficient water to require the replenishment of watering system 8 from an external water source. If C_{ah} is greater than C_1 , then cell watering may occur. Pressurised water is available to reservoir 18 and supplies water to cells 14. Controller 39 monitors C_{ah} and causes light 40 to alert the operator to the need for water ("Need Water" light 40 on). If C_{ah} is less than C_1 , the amount of overcharge has likely not caused a great deal of electrolyte electrolysis and therefore no watering need occur. When C_{ah} is greater than C_2 , the charger is disabled unless hose 24 is connected to deioniser 22. The battery is charged until an end of charge (EOC) is detected. Controller 39 then begins a first timer T_1 , which is a function of the evolution of gas from the recently overcharged battery and the cell cap configuration. Typical times are about 44 minutes.

Moving to Figure 8, power is supplied to the solenoid valve 38/switch 36 couple. If the level of float 34 senses that reservoir 18 needs water, then switch 36 causes valve 38 to open and admit water to reservoir 18. After reservoir 18 is filled, switch 36 causes valve 38 to close. Each opening and closing appears as a voltage pulse. Controller 39 records these pulses in a memory. As cells 14 fill with water, the water within reservoir 18 causes float 34 to drop and to open valve 38. The repeated opening and closing of valve 38 produces a cycling pattern as illustrated in Figure 10. Five on/off cycles are usually sufficient to assume the system is working properly.

Controller 39 senses the solenoid voltage (SV) for each watering ramp i (Sense line). If any line i fails to record 5 pulses (SVs), then controller 39 records a failure event and displays a fault ("Need Water" light 40 blinks). Controller 39 can also monitor the pump power (Pump Pwr), solenoid power (Solenoid Pwr), hose detect or charger cord detect (Charger Cord Det) to precisely determine the location of various faults. While a single continuous or blinking light 40 has been used to display the condition of the watering system, other more detailed display means are also possible.

After the solenoids stop cycling on and off, controller 39 senses that cells 14 are completely filled. After a sufficient period of time has elapsed for flow through (usually 30 seconds), controller 39 removes power from valve 38/switch 36 and pump 30 and resets C_{ah} to 0. If controller 39 has not record any component failures (the presence of 5 or more SVs for each watering ramp or other system fault), then light 40 is turned off. This signals the operator that the watering system has functioned properly and the cells are filled.

Claims

1. A battery watering system comprising:
a battery (10) having a plurality of cells (14) connected in series;
a watering cap (16) associated with each said cell (14);
a reservoir (18) communicating water from said watering caps (16) through a first watering con-

duit (28); and

a reversible pump (30) communicating water from said reservoir (16) to a second watering conduit (26), and said second watering conduit (26) communicating water to said watering caps (16), said pump (30) being positioned below said watering caps (16) whereby water within said watering caps (16) and said second watering conduit (26) drains through said pump (30) by siphon.

2. A battery watering system as claimed in claim 1 and further comprising a controller sensing the need for cell watering and operating said pump to provide water to said cell.
3. A battery watering system as claimed in claim 2 and further comprising a water level sensor sensing the water level within said reservoir and causing a valve to admit water into said reservoir when the water within said reservoir is low.
4. A battery watering system as claimed in claim 3, wherein said controller records the operation of said valve and signals an operator in the event said battery watering system fails.
5. A battery watering system as claimed in claim 1, wherein said battery comprises a plurality of watering ramps, each said watering ramp supplies water to one or more modules, said module comprising a plurality of said cells; each said watering ramp being associated with one said reservoir, each said watering ramp being electrically isolated from the other said watering ramps.
6. A battery watering system comprising:
a battery having a plurality of modules connected in series, each said module having a plurality of cells connected in series;
a watering cap associated with each said cell;
one or more watering ramps providing water to said modules;
a reservoir associated with each said watering ramp communicating water from said watering caps through a first watering conduit;
a valve associated with each said watering ramp operable to admit deionised water into said reservoir;
a water level sensor sensing the water level within each said reservoir and causing said valve to open and admit water into said reservoir when the water within said reservoir is low;
a reversible pump associated with each said watering ramp communicating water from said reservoir to a second watering conduit, said second watering conduit communicating water to said watering caps of said module, said pump being positioned below said watering caps whereby water within said watering caps and said second watering

conduit drains through said pump by siphon; and
a controller sensing the need for cell watering
and operating said pump to provide water to said
cells, said controller recording the operation of said
valve to determine the normal operation of said
watering system and signalling an operator of suc-
cessful and unsuccessful battery watering.
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7. A method of watering a battery comprising the steps
of:
charging said battery and recording the amp
hours of overcharge;
signally a "need water" alert to an operator if
said overcharge amp hours exceeds an amount;
sensing the connection of a pressurised
water source to a water inlet and preventing battery
charging in the event said connection is absent;
operating a pump to provide water to said
cells;
operating a valve to admit water into a reser-
voir and recording the operation of said valve;
signalling a "failure" alert to said operator if
said valve or pump fail to operate properly; and
signalling a successful battery watering if
said watering system operates properly.
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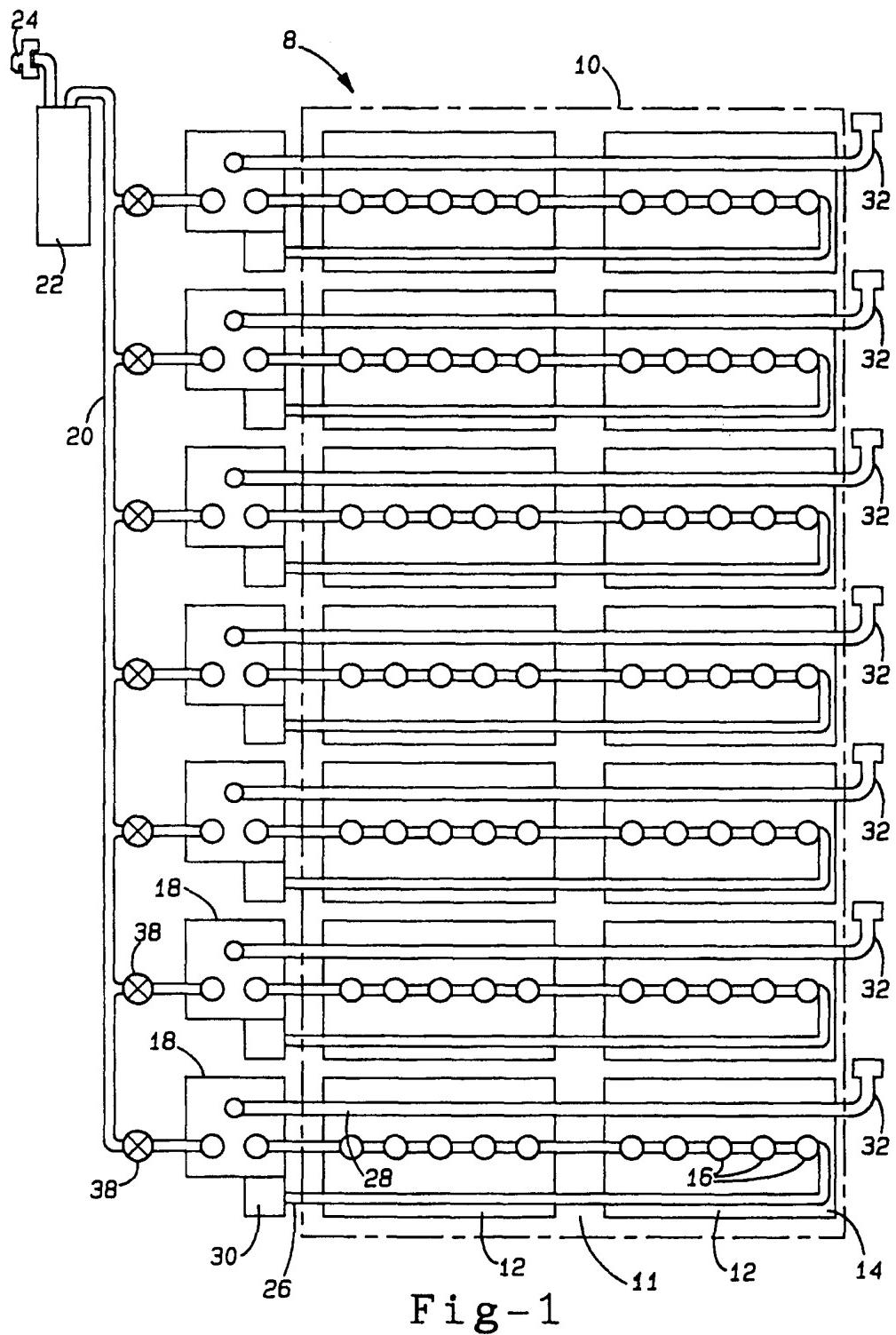


Fig-1

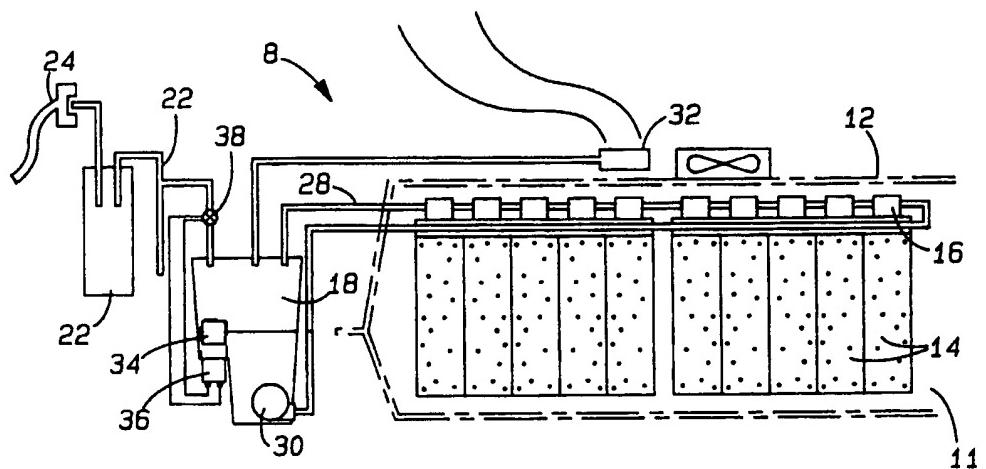


Fig-2

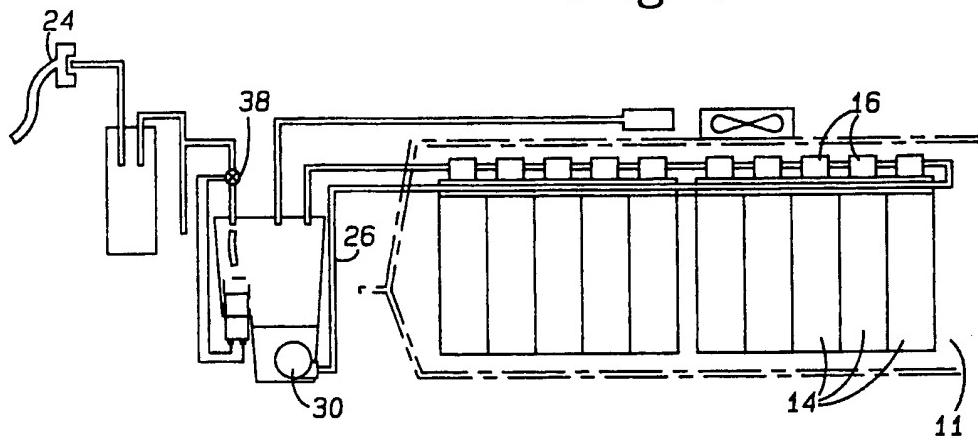


Fig-3

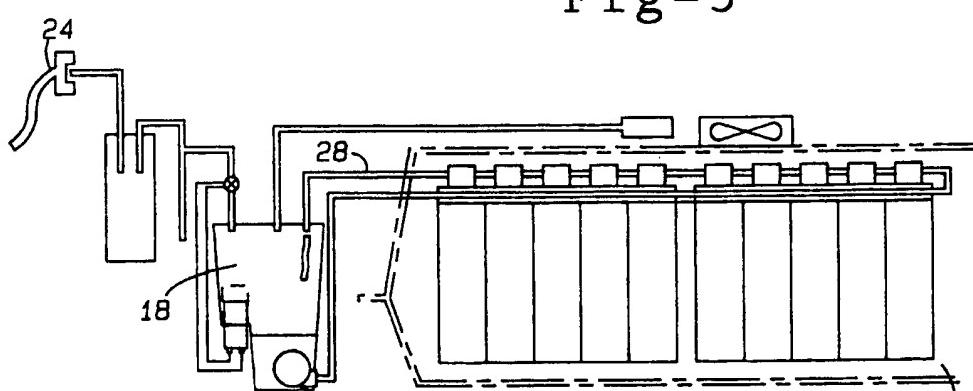


Fig-4

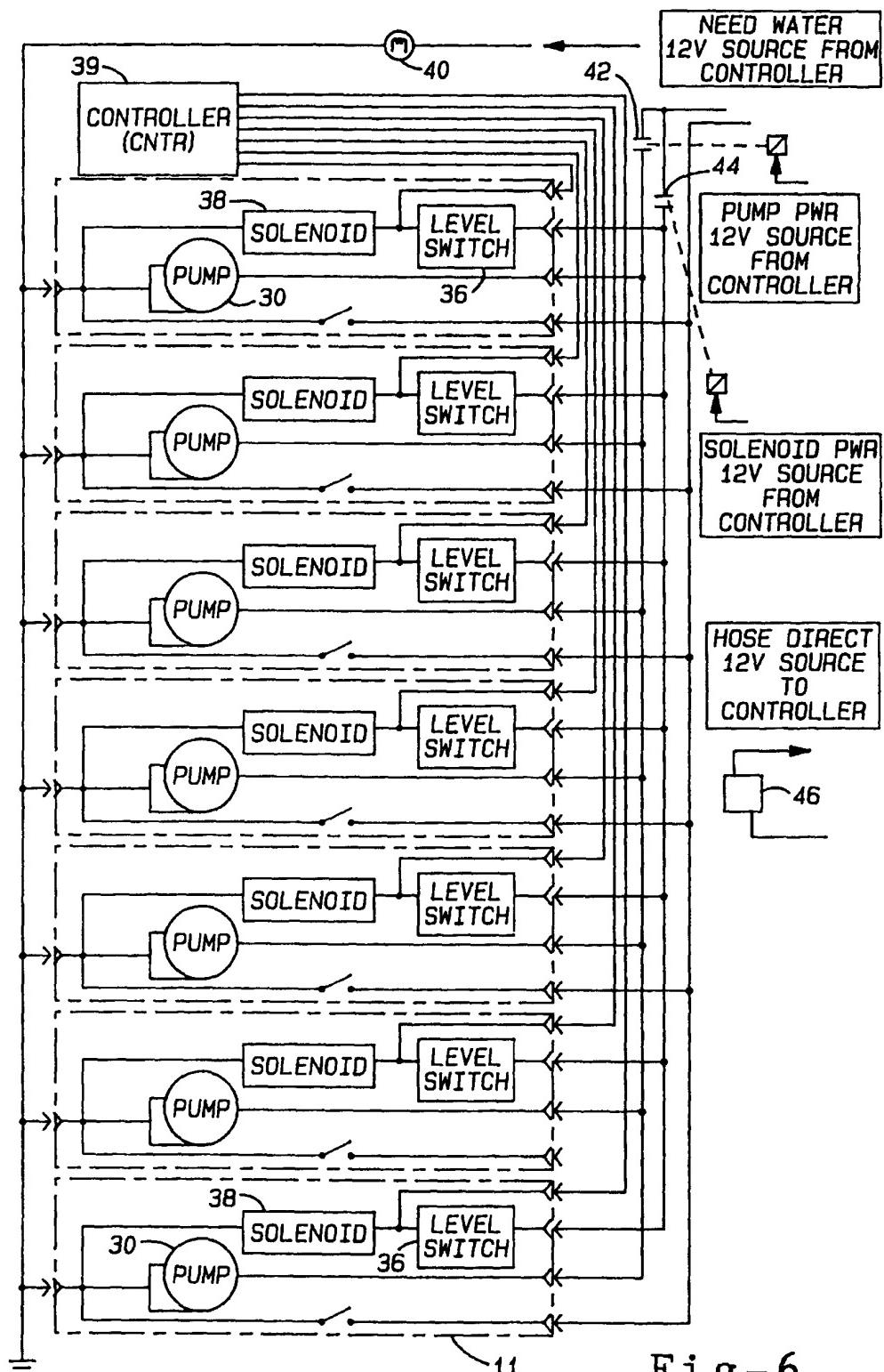


Fig - 6

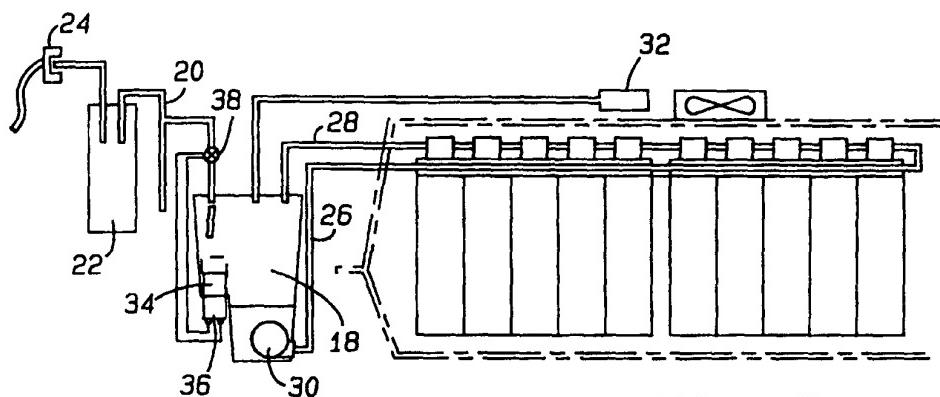


Fig-5

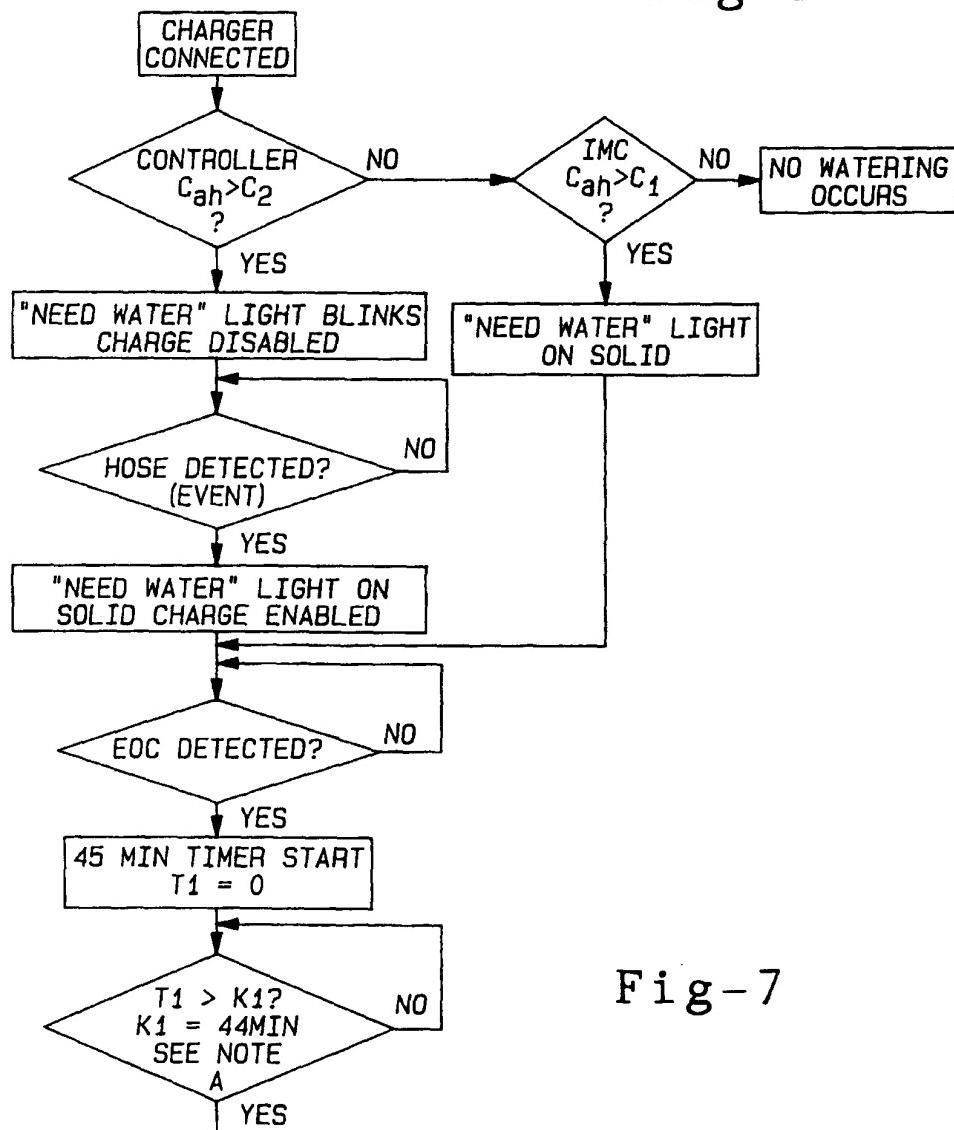
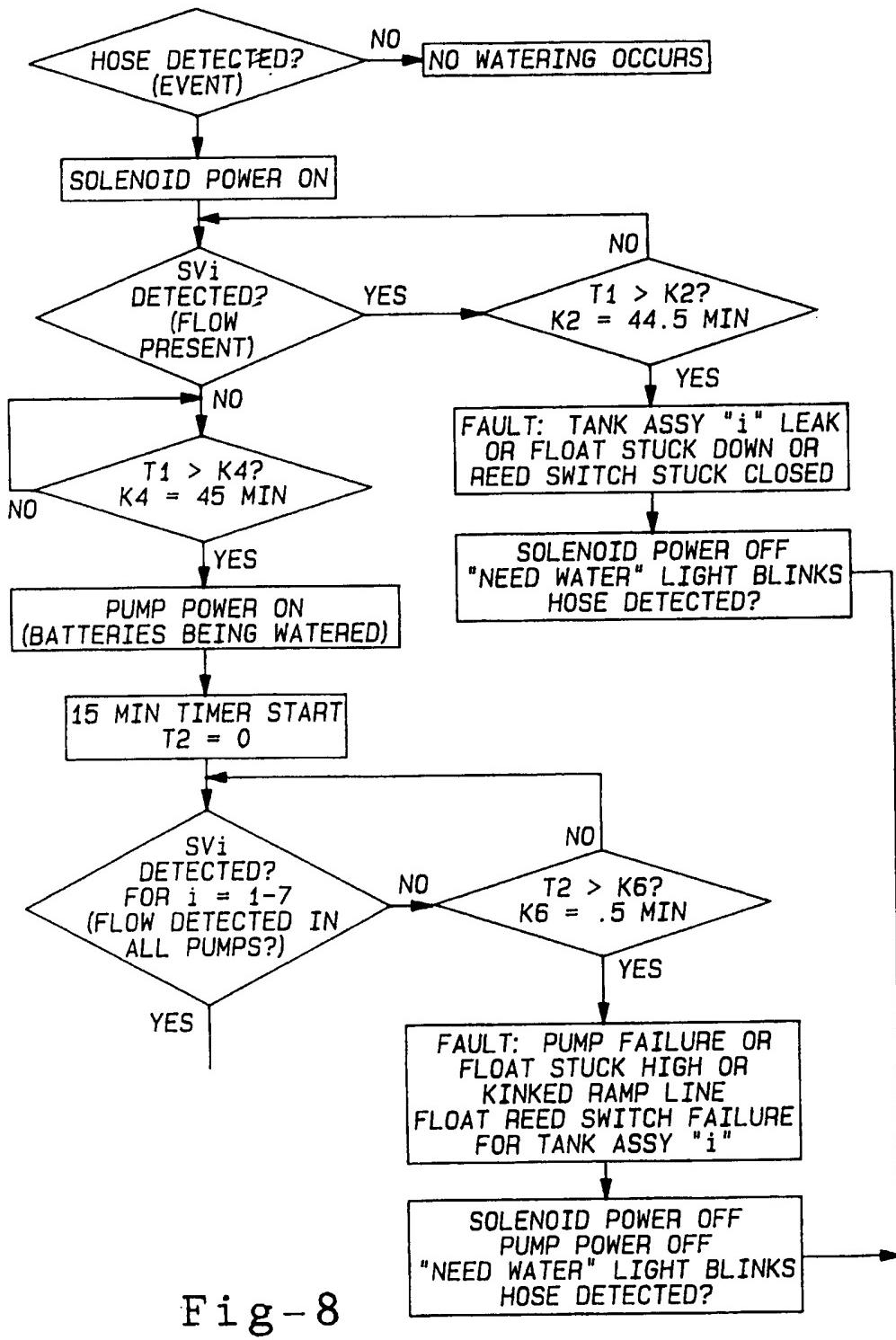


Fig-7



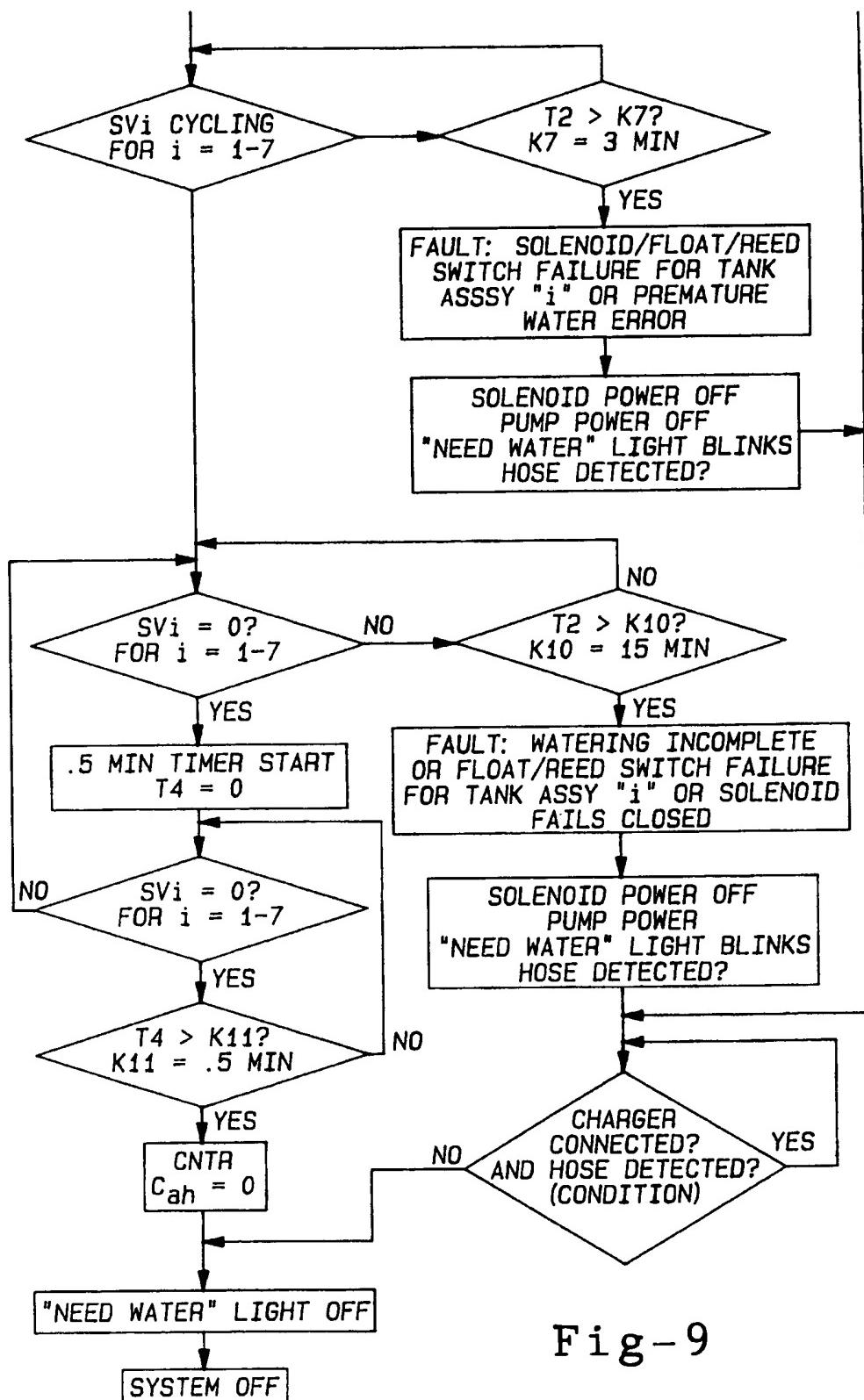


Fig-9

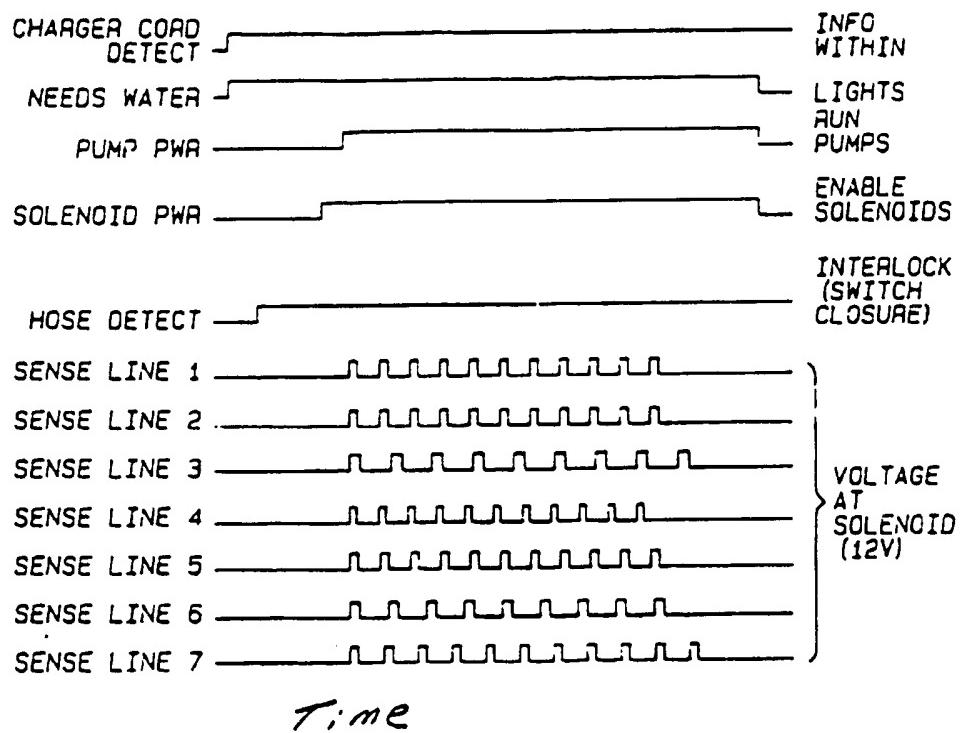


Fig-10



European Patent
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EUROPEAN SEARCH REPORT

Application Number
EP 95 30 9374

DOCUMENTS CONSIDERED TO BE RELEVANT			CLASSIFICATION OF THE APPLICATION (Int.Cl.6)						
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim							
A	PATENT ABSTRACTS OF JAPAN vol. 005, no. 040 (E-049), 17 March 1981 & JP-A-55 163767 (YUASA BATTERY CO LTD), 20 December 1980, * abstract * --- A EP-A-0 009 990 (CHLORIDE GROUP LTD) 16 April 1980 * claims 1-9 * -----	1-7	H01M2/36						
			TECHNICAL FIELDS SEARCHED (Int.Cl.6)						
			H01M						
<p>The present search report has been drawn up for all claims</p> <table border="1" style="width: 100%; border-collapse: collapse;"> <tr> <td style="width: 33%;">Place of search</td> <td style="width: 33%;">Date of completion of the search</td> <td style="width: 34%;">Examiner</td> </tr> <tr> <td>THE HAGUE</td> <td>26 April 1996</td> <td>Battistig, M</td> </tr> </table> <p>CATEGORY OF CITED DOCUMENTS</p> <p>X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document</p> <p>T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document</p>				Place of search	Date of completion of the search	Examiner	THE HAGUE	26 April 1996	Battistig, M
Place of search	Date of completion of the search	Examiner							
THE HAGUE	26 April 1996	Battistig, M							